HVOF on Navy Landing Gear Forges Ahead

New Coating to Replace Chrome Plating

Naval Air Depot (NADEP) Jacksonville, FL recently completed a successful test flight of the first carrier-based aircraft to use high-velocity oxygen-fuel (HVOF) coating on the landing gear.

The new HVOF coating process was used on the starboard main landing gear piston of an EA-6B Prowler and replaces the more expensive and toxic chrome plating. This test flight represents the culmination of five years of testing and evaluation by the Depot's Materials Engineering Division, including many technical discussions and debates throughout the Naval Air Systems Command (NAVAIR).

Background

The electrolytic hard chrome (EHC) plating process is used as a wear-resistant and corrosion-resistant coating for a wide variety of aircraft and engine components. In fact, the Department of Defense (DoD) depots and commercial repair shops used it even more widely, both for replacing the EHC coating after stripping and inspection of the component, and as an approved repair procedure for worn part dimensional restoration that may or may not have been chrome plated. However, hard chrome plating utilizes hexavalent chromium (a known carcinogen) and is targeted by the Occupational Safety and Health Administration for a reduction in permissible exposure limits by as much as two orders of magnitude. Therefore, the cost of chrome plating is expected to increase dramatically on the hard chrome plating operation and disposal of materials.

As a result, the Hard Chrome Alternatives Team (HCAT), the Environmental Strategic Technology Certification Program (ESTCP) and the Joint Group on Pollution Prevention (JG-PP) which includes DoD Services Representatives, Program Managers and Original Equipment Manufacturers, initiated a project to validate the HVOF thermal spray process, as an environmentally-acceptable and superior-performance alternative to EHC.

The EA-6B Prowler was the first aircraft platform to receive the new HVOF coating on its landing gear.

U.S. Navy photo by Photographer's Mate 2nd Class Danny Ewing Jr.

The EA-6B Prowler.
U.S. Navy photo by Photographer's Mate 3rd Class Milosz Reterski

THE HVOF PROCESS

High-velocity oxygen-fuel (HVOF) thermal spray process utilizes the combustion of a fuel gas and an oxidizer to generate combustion products that form the accelerant gas. As a result of this combustion process, the energy released produces high pressure in the carbide powder that is being fed into the flame. The HVOF gun uses a convergent-divergent nozzle and when combined with the combustion process, provides sufficient energy to drive the accelerant gas to supersonic velocity (Figure 1). The resultant high particle temperature and high particle velocity produces coatings with less porosity (high density), high hardness, and higher adhesive bonding strength than those generally attainable with other thermal spray processes. This is especially beneficial in corrosion resistance applications, such as the Navy operational environment, where a dense barrier to corrosion is needed.

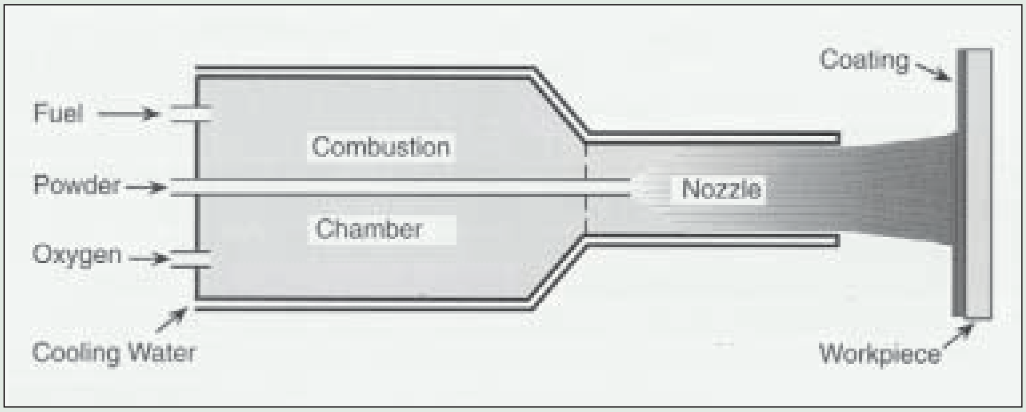

FIGURE 1: The High-Velocity Oxygen-Fuel Process.

An EA-6B Prowler takes off for first flight following depot maintenance with HVOF coated main landing gear strut assembly installed.

Photo by Victor Pitts, Public Affairs Office, NAS Jacksonville

The HVOF process produces a coating that is more dense and corrosion resistant than chrome, is more economical and environmentally safe, and can be more quickly applied.

Concerns

The HVOF process is typically used on land-based aircraft, both in the private sector and in the military. However, keeping carrier-based aircraft in top condition is difficult due to additional stresses experienced when landing and operating in a corrosive, saltwater environment. As part of project demonstration/validation phase, actual aircraft components were used in real-time scenarios and evaluated. In October 1999, an EA-6B main landing gear strut assembly was coated with HVOF tungsten carbide cobalt coating at NADEP Jacksonville and a flight clearance was requested from the EA-6B Class Desk. However, issues with spalling of the coating at high stresses and strains raised concerns within NAVAIR about HVOF coatings on carrier-based aircraft landing gear. As a result, the flight clearance was put on hold pending further assessment.

GETTING LEAN WITH HVOF

HVOF fits into NADEP Jacksonville's efforts to go "LEAN". LEAN is one of three methodologies being used by the Navy to sustain cost-wise readiness by increasing throughput, decreasing turn-around-time, reducing cost and simplifying work processes with existing resources. LEAN's primary focus is to identify and eliminate constraints in the generation of a quality product. LEAN helps transform production processes from an inefficient push system to a more efficient and less costly flow and pull system. LEAN is about working smarter, not harder. HVOF is certainly a smarter, LEANer alternative to toxic chrome plating.

Major Milestone Accomplished

On 14 September 2004, an EA-6B Prowler from the VAQ-138 squadron landed on the aircraft carrier USS CARL VINSON. This marks the first time that a carrier-based aircraft has made an arrested landing with HVOF coating on the main landing gear strut assembly. This significant accomplishment will provide crucial data to the HCAT, NAVAIR, and Program Managers (i.e., EA-6B, Joint Strike Fighter (JSF)) for future transition of this technology as a replacement for EHC.

The Benefits of HVOF Coatings

Test data show that HVOF coatings (i.e., tungsten carbide cobalt) performed as well as (and in most cases better than) hard chrome. This is certainly true in critical areas such as hardness, wear, fatigue, corrosion, hydraulic testing, and extended flight testing. The benefits of HVOF coatings include:

- Elimination of hexavalent chromium emissions,

Installed HVOF coated main landing gear strut assembly with red stencil indicating HVOF test article.

Photo by Brad Youngers, Materials Engineering Laboratory, NADEP Jacksonville

Test data show that HVOF coatings performed as well as (and in most cases better than) hard chrome.

- Reduction in toxic waste disposal costs,
- Reduction in turn-around-time (Plating a large object (such as a landing gear) with chrome typically takes about 40 hours. The HVOF application can be completed in one work shift.),
- Decrease in component repair and frequency due to the superior performance of HVOF coatings,
- Increase in mission readiness, and
- A safer working environment for maintenance workers.

HVOF coated main landing gear strut assembly installed on starboard position as aircraft completes depot maintenance at NADEP Jacksonville.

Photo by Jon Devereaux, Materials Engineering Laboratory, NADEP Jacksonville

Summary

The HVOF process produces a coating (i.e., tungsten carbide cobalt) that is more dense and corrosive resistant than chrome, is more economically and environmentally safe, and can be more quickly applied. Demonstrations are continuing on a variety of aircraft components such as actuators and dynamic components.

A NAVAIR letter (Ser 4.1.1.1.3/318 dated 27 May 2003) approved the use of HVOF coatings on P-3 main landing gear assemblies, nose landing gear assemblies and bomb bay door actuator assemblies. Additional transition is anticipated pending the release of a NAVAIR Guidance Document issued by AIR-4.3.4 (Materials Engineering) with concurrence from AIR-4.3 (Structures) that will cover implementation on landing gear components.

The recently published Aerospace Materials Specification (AMS) 2449 for grinding of HVOF coatings applied to high strength steels was written and expedited by Jon Devereaux, Materials Engineer and HVOF Project Coordinator at NADEP Jacksonville. This specification will be used as the international governing technical document for the grinding of these types of coatings on aircraft landing gear worldwide. ⚓

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